Physical Differences Between Xenon and Krypton Operation on a Magnetically-Shielded Hall Thruster*

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Hall thrusters are an electric propulsion device with high thrust density, moderate specific impulse, and relatively long operational lifetimes. This last trait has been enabled by magnetic shielding, a technology that prevents energetic ions from eroding thruster channels. Traditionally, Hall thrusters have operated on xenon, but krypton provides an attractive alternative at its lower cost and higher specific impulse for a given power. However, the use of krypton has been limited by its poor efficiency compared to xenon on both unshielded[1] (US) and magnetically-shielded[2] (MS) Hall thrusters. This study investigates why this performance gap exists on shielded Hall thrusters and how it compares to unshielded thrusters.

The H9, a 9-kW MS Hall thruster, was operated in the Large Vacuum Test Facility at the University of Michigan at 300 V and 15 A on both xenon and krypton. A probe suite and a thrust stand measured various efficiency contributions towards the anode efficiency and the anode efficiency itself. Results from this study indicated that mass utilization efficiency and current utilization efficiency are the main reasons why the krypton efficiency is lower than that of xenon; both the mass and current utilization efficiencies were lower for krypton than xenon by about 12%.[2] The gap in mass utilization efficiency is comparable to that on an US thruster, but the gap in current utilization efficiency is about 9% larger. [1,2]

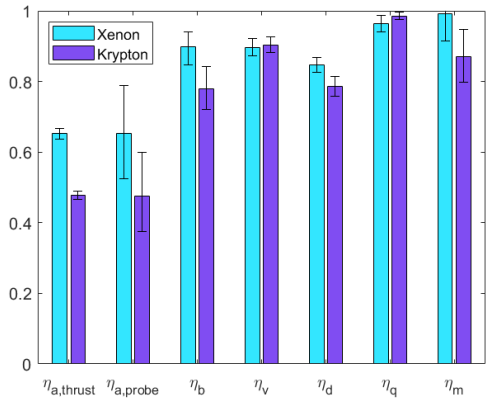

Figure 1 – Efficiency contributions for the H9 running on xenon and krypton at 300 V, 15 A.

The similar gaps in mass utilization efficiencies for the US and MS case are surprising considering the differences in magnetic field topology. A comparison of the effect of electron temperature on the ionization rate is made to better understand this phenomenon. A given change in electron temperature leads to a larger change in ionization cross-section for krypton than for xenon.[3] Because the profile of electron temperature on a MS thruster is higher along centerline but lower along the walls, the net effect on the krypton efficiency on a US thruster compared to a MS thruster is approximately the same. The results from this study can be used to better optimize future operation of magnetically-shielded Hall thrusters.

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References

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[3] Bordage, M. C., et al. (2013). Comparisons of sets of electron-neutral scattering cross sections and swarm parameters in noble gases: III. Krypton and xenon. *Journal of Physics D: Applied Physics*, *46*(33).